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(54) **HIGH BANDWIDTH DIFFERENTIAL LEAD WITH DEVICE CONNECTION**

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H01B 1/00 (2006.01)
G01R 1/04 (2006.01)

(52) **U.S. Cl.**
CPC ***G01R 1/067*** (2013.01); ***G01R 1/06772*** (2013.01); ***H01B 1/00*** (2013.01); *G01R 1/0416* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

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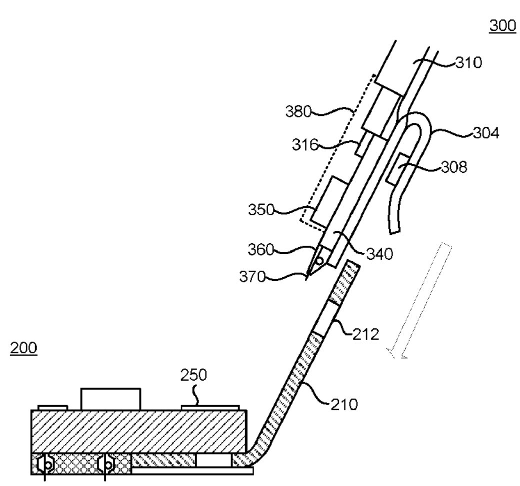
(57) **ABSTRACT**

A high bandwidth solder-less lead may be connected to an electrical device having land patterns so that signals on the device may be more easily measured through the lead. The lead includes an attachment mechanism to mount the lead on the device, a microspring housing and at least one microspring. The microspring connects one of the particular land patterns on the device to the lead where it may be easier to couple to a measurement device than to the electrical device itself. The lead may be coupled to a flexible electrical conduit to make attaching to the testing device even easier. In other versions, a uniform connector may be temporarily attached to the solder-less lead to test the device. Then the connector may be disconnected from the first lead and connected to another lead to test another area of the device.

14 Claims, 5 Drawing Sheets



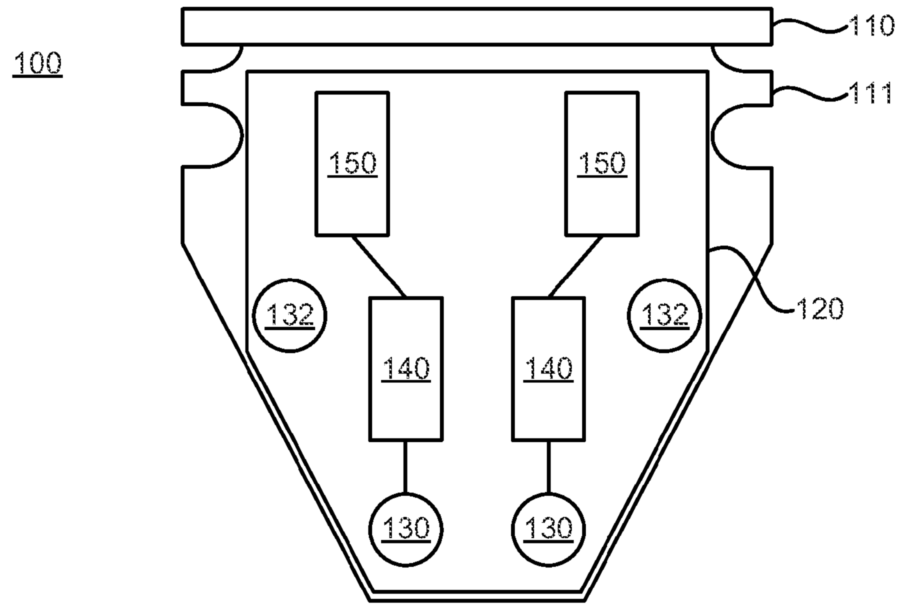


FIGURE 1

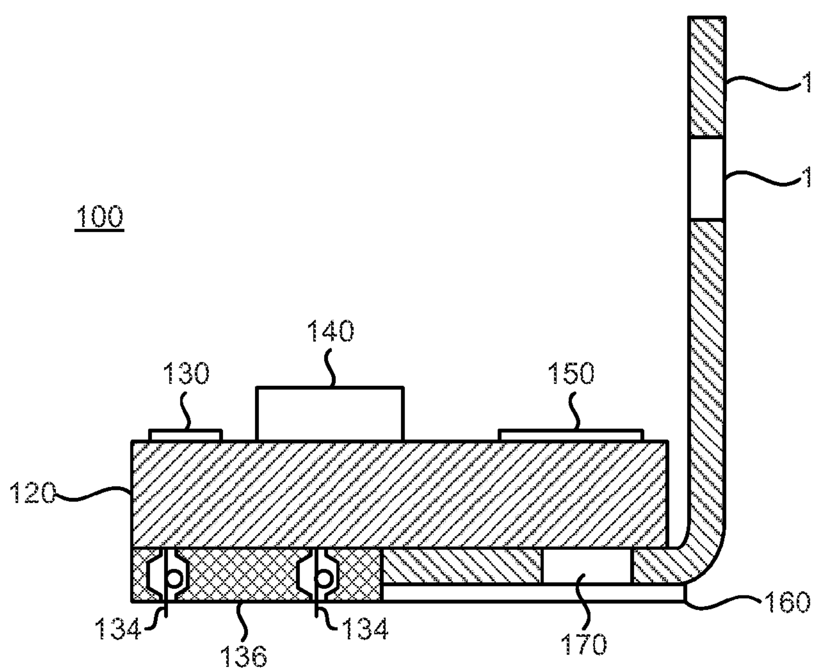


FIGURE 2

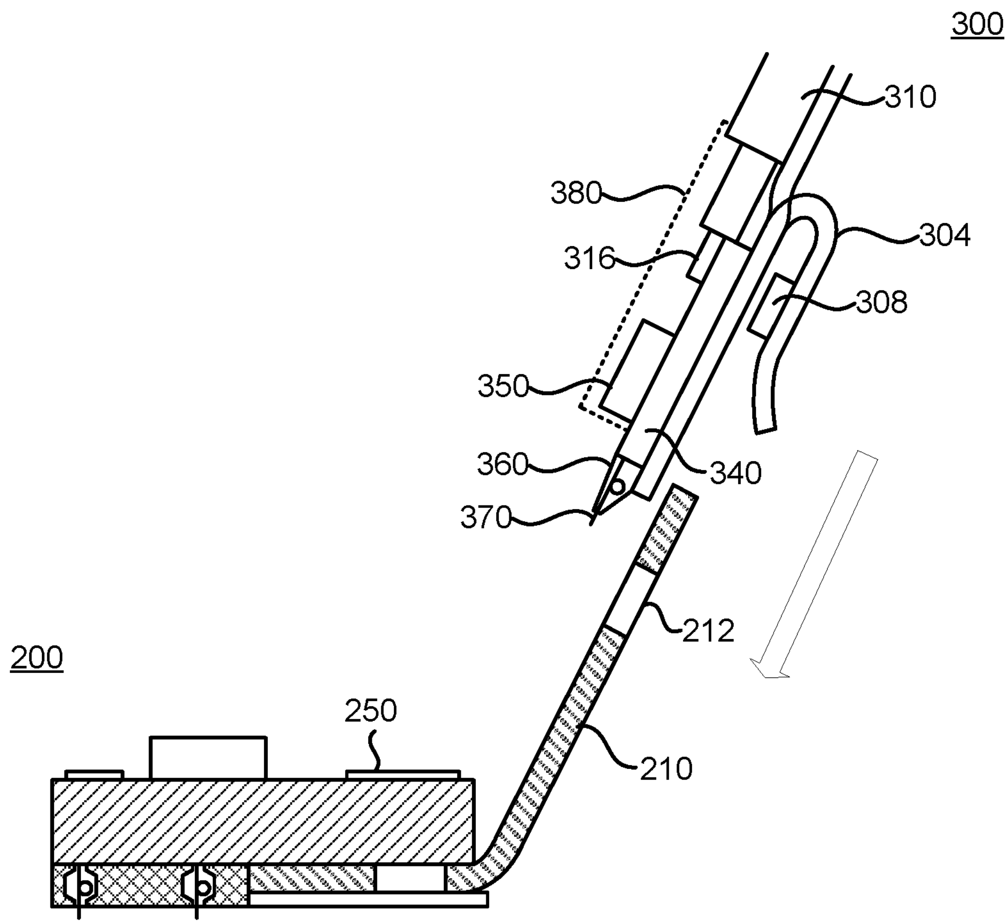


FIGURE 3

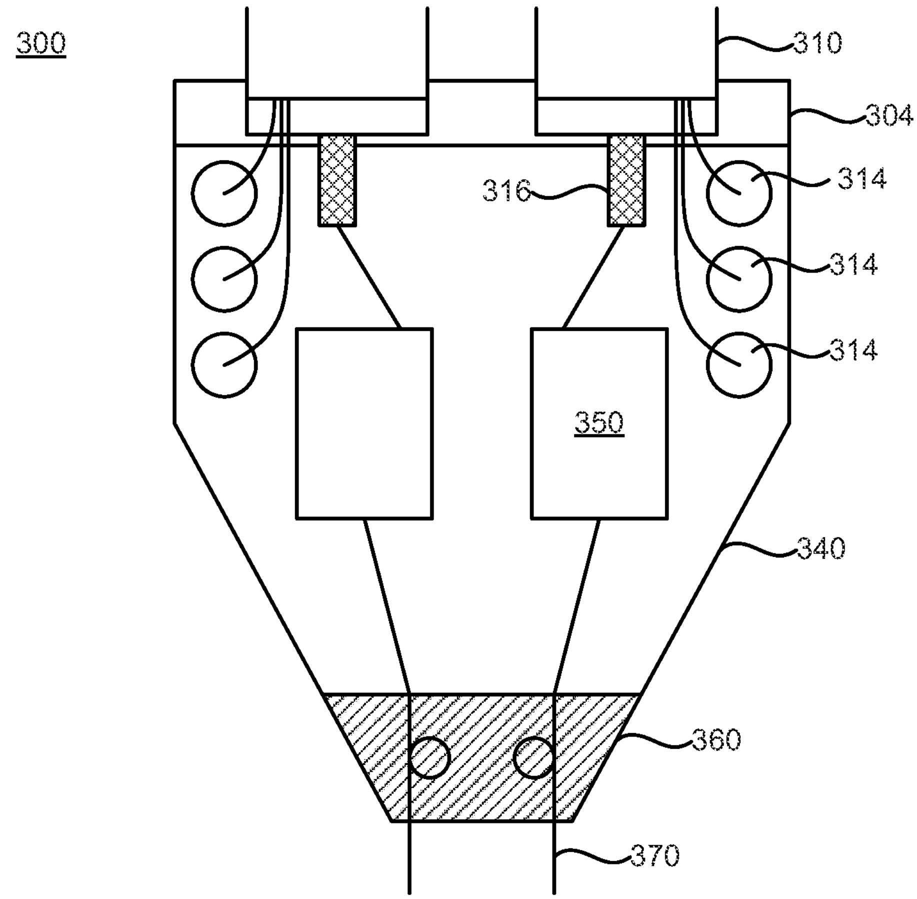


FIGURE 4

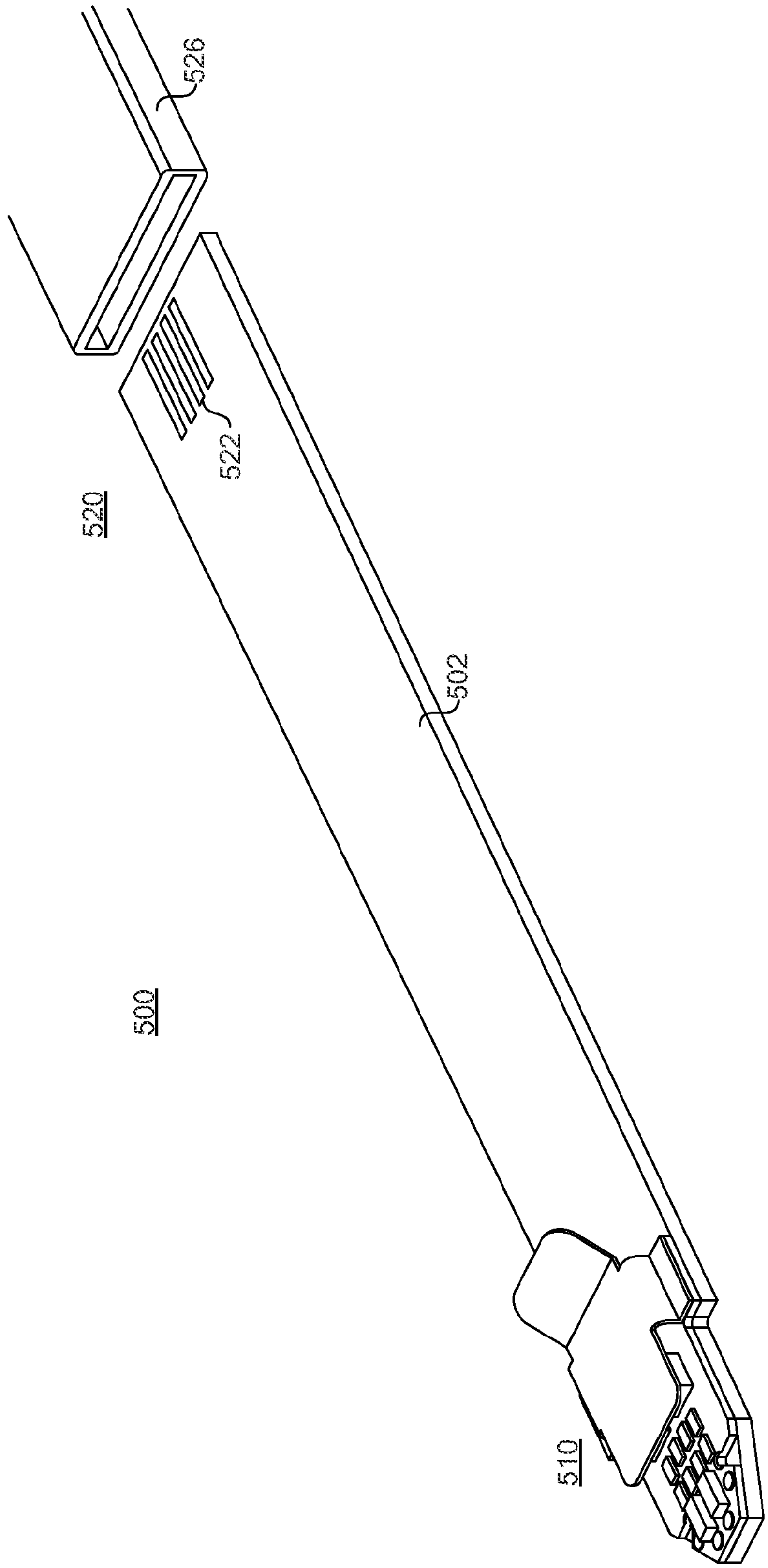


FIGURE 5

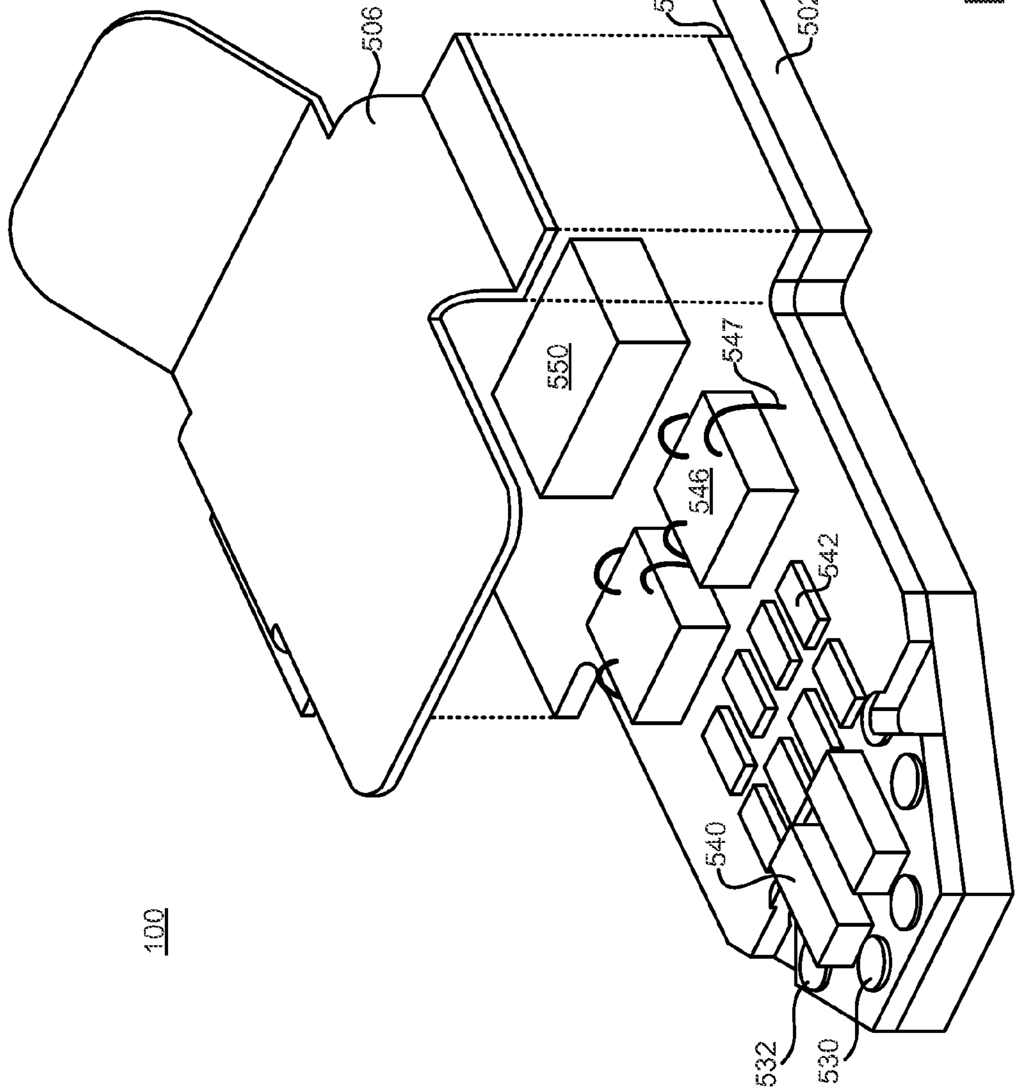


FIGURE 6

HIGH BANDWIDTH DIFFERENTIAL LEAD WITH DEVICE CONNECTION

FIELD OF THE INVENTION

This disclosure is directed to lead assemblies, and, more particularly, to devices that couple test equipment to devices to be tested through such lead assemblies.

BACKGROUND

Electrical devices are often tested, especially during development, production, or when they are not working properly. Test equipment provides information about the operation of the devices. Test equipment may include meters, probes, logic analyzers, and scopes such as oscilloscopes, for example.

It is sometimes difficult to accurately measure high frequency signals generated by a device because of, among other reasons, the difficulty in reliably connecting or coupling the device under test to the measuring device. For the best results, the devices should be solidly electrically connected to the test device. For example, a preferred method for measuring test signals having frequencies between 6-10 GHz is to first attach a small solder-in lead to various testing points in the circuit. Then, the lead may be coupled to a probe of a high-frequency testing device and the signals of the device are measured. In practice, the probe may be manually coupled to a number of separate soldered-in leads so that the signals at the testing points may be measured.

Even though soldering such connections is the best currently available method, it is not without problems. Installation of such devices by soldering the typically small leads is problematic, and can lead to damage to either the lead, the device, or both. Damaging either may be costly, either in equipment or in time lost to fix the damage. Further, solder-in leads tend to be small and are damaged easily, and it is easy to break the fine leads that are typically coupled to coax cable connectors. Costs are another issue, both in device and labor costs, as the leads are expensive and take time to install properly.

Embodiments of the invention address these and other limitations of the prior art.

SUMMARY OF THE INVENTION

Aspects of the invention include a high bandwidth solder-less lead mountable to an electrical device having land patterns. The lead includes an attachment mechanism to attach the lead to the device, a microspring housing, and at least one microspring carried in the housing. A portion of the microspring extends beyond the microspring housing to electrically couple to one of the land patterns of the electrical device. In some embodiments there may be multiple microsprings coupling different signals from the device to the solder-less lead. The signals may include ground signals. The lead may be attached to a flexible conduit that is readily attachable to a test device, such as through a socket.

Other aspects include a combination of a solder-less lead having at least one microspring carried in a housing for coupling to an electrical device in which the lead is removably or temporarily coupled to a connector. The connector further includes another microspring carried in another housing. The solder-less lead may be permanently attached to the electrical device, while the connector may be temporarily connected to a first lead, and then connected to a second lead to measure a second set of signals.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top view of a head of a lead assembly for attaching to a device being tested according to embodiments of the invention.

FIG. **2** is a is a side view of the lead assembly of FIG. **1** attached to a connection bracket according to embodiments of the invention.

FIG. **3** is a side view of an example lead assembly as it is being coupled to a head end of a cable assembly according to embodiments of the invention.

FIG. **4** is a top view of the head end of the cable assembly according to embodiments of the invention.

FIG. **5** is a perspective view of a lead assembly for attaching to a device according to other embodiments of the invention.

FIG. **6** is a perspective view of a head of the lead assembly of FIG. **5** according to embodiments of the invention.

DETAILED DESCRIPTION

Embodiments of the invention are now described beginning with reference to FIGS. **1** and **2**. FIG. **1** is a top view of a head of a lead assembly for attaching to a device being tested according to embodiments of the invention, and FIG. **2** is a side view of the same device.

A head assembly **100**, generally, is structured to physically attach to a device under test (DUT) (not illustrated). Such devices may include those devices that have high-speed RF signals on the board, In many embodiments the device will have an exposed printed circuit (PC) board that terminates in test points or includes particular land patterns. Land patterns are areas for electrical connection, such as for connecting a surface mounted Integrated Circuit (IC) to a particular device. Land patterns may also be used to couple to a testing device, or to a probe or other lead coupled to the testing device. Land patterns are oftentimes used as soldering points to connect the DUT to a soldered lead assembly. Land patterns could be, for example, flat spots of metal or solder-covered metal, or could be raised bumps on a PC board of the DUT. Bumps could be bumps of a Ball Grid Array (BGA), for instance. Of course, the examples described herein are merely examples, and embodiments of the invention may be used in various and multiple ways without deviating from the inventive scope.

The test lead **100** of FIG. **1** includes a support bracket **110**, which is more apparent in FIG. **2**. The support bracket **110** may be formed of metal or other supporting material.

Coupled to the support bracket **110** is a support board, such as a PC board **120**. The PC board **120** may be soldered to the bracket **110** through solder tabs **111** or otherwise attached to the support bracket **110**. The PC board **120** has components mounted thereon. For instance, a set of resistors **140**, or other components, may be mounted between a set of signal pads **130** and a set of probing signal pads **150**. A set of ground pads **132** may also be included. As described below, the set of signal pads **130** may be coupled to the set of land patterns of the DUT, and a set of probing signal pads **150** provides an area for measurement by a probe of a measurement device. The probing signal pads **150** are typically larger than the land patterns on the DUT, which makes it easier to couple to the test probe. The probing signal pads **150** may also be referred to as differential pads because they are typically placed in pairs, and the pair receives differential signals, one on each pad of the pair.

The ground pads **132** may likewise be coupled to signal grounds of the DUT, as described below.

As shown in FIG. **2**, springs **134** may be connected to an under-side of the signal pads **130** and ground pads **132** through a via in the PC board **120**. The springs **134** make an electrical connection between the signal pads **130**, ground pads **132** and their respective land patterns on the DUT. The springs **134** may be metal having a relatively low resistance. The springs **134** may be shaped as microsprings, and capable of carrying high bandwidth signals from the land patterns of the DUT to the signal pads **130** and ground pads **132**, respectively.

The springs **134** may be supported by an insulated spring housing **136**. The spring housing **136** maybe be a plastic of sufficient strength and stiffness to properly support the springs **134**. The spring housing **136** may be made of thermoplastic polyetherimide such as Ultem plastic available from SABIC, or from any other suitable material.

The springs **134** may be spaced to exactly match the spacing of the land patterns of the DUT. In some embodiments, multiple test leads **100** may be available, each having different spacing between the springs **134**. In those embodiments, a test engineer selects the proper test lead **100** having the desired spacing. In other embodiments, device manufacturers may develop one or more standard spacings that are based on the widths between the springs **134**.

The test lead **100** also includes an attachment mechanism **160**, such as adhesive foam, epoxy, or a clamp, so that the test lead **100** may be attached to the DUT. In some embodiments the test lead **100** may be mounted on the DUT permanently.

In practice, to mount the test lead **100** to the DUT, the adhesive foam **160** is exposed by removing a protective covering. In some embodiments the same or another protective covering also covers and protects the springs **134**, and removing the covering or coverings exposes a bottom portion of the springs. After uncovering the adhesive foam **160**, the test lead **100** is lowered toward the DUT so that the exposed springs **134** touch the land patterns in a mating fashion. Then, the test lead **100** is pressed into place, making a secure connection to the DUT with the adhesive foam **160**, and simultaneously making a secure electrical connection between the land patterns of the DUT and the springs **134**. As described above, the springs **134** make a secure electrical connection between the land patterns and the under-side of the signal pads **130** and ground pads **132** of the test lead **100**. Further, a top side of the signal pads **130** and ground pads **132** may also include surfaces so that wires or other electrical connections may be made to other portions of the DUT. Or, in some embodiments, the test lead **100** may be attached to the DUT by the adhesive foam **160**, or other methods, near the desired land patterns, and the land patterns may be connected to the top of the signal pads **130** and ground pads **132** with soldered wires, and not necessarily through the springs **134**.

With reference to FIGS. **3** and **4**, described is a connector assembly **300** that may be matingly and removably coupled to the test lead **200**, which may be an example of the lead **100** of FIG. **1**. In other words, after the test lead **200** has been attached to the DUT, using the methods described above, a connector assembly **300** may be temporarily attached to test lead **200** and be used to electrically connect it to the measurement device through a cable, such as a pair of coaxial cables **310**, so that measurements of the DUT may be made. In this way, a single probe may be able to easily attach to multiple test leads **200** mounted on a DUT in a serial manner, i.e., first testing a first test lead, then removing it from the first test lead and attaching it to another, etc. After the testing is complete, the test lead **200** may be left attached to the DUT, while the connector assembly **300** may be used to test other devices.

The test lead **200** of FIG. **3** differs from the test lead **100** of FIG. **1** by the position of a bracket **210**. More specifically, the bracket **210** is bent away from the main body of the test lead **200**. As described above, the bracket **210** may be made from a yieldable material, such as a soft metal, that may be relatively easily moved, such as by manual pressure, but remains in place once moved. One benefit to having a positionable bracket **210** is that it allows the connector assembly **300** to be attached to the test lead **200** even though there may be an interfering structure that would otherwise hinder attaching the connector assembly **300**. Because it is unknown in advance what hindrances there may be near a test site of the DUT, having a bracket **210** that is positionable may allow the test lead **200** to be used with more test sites of a DUT than if the bracket were not positionable.

The connector assembly of FIGS. **3** and **4** includes a pair of springs **370** that are used to electrically connect to the probing signal pads **250** of the lead **200**. Recall from above that the probing signal pads **250** are coupled through the lead **200** to land patterns of the DUT. The pair of springs **370** then connect the probing signal pads **250** to a pair of coaxial cables **310**, which conveys the signals from land patterns of the DUT to a probe of the measurement device (not illustrated) so that the DUT may be measured. Ground signals may be carried by the bracket **210**, or may be coupled to ground pads **314** in another manner. The coaxial cables **310** may be skew matched for better signal integrity.

The springs **370** may be the same or similar to the springs **134** of FIG. **2**, except the springs **370** are positioned to project from the connector assembly **300** directly opposite the coaxial cables **310**. The springs **370** are held in a spring housing **360**. The housing **360** maybe be a plastic of sufficient strength and stiffness to properly support the springs **370**. Similar to the spring housing **136** described above, the spring housing **360** may be made of thermoplastic polyetherimide. The spring housing **360** may have a shape at one end to facilitate the springs **370** to contact the probing signal pads **250** no matter what position the bracket **210** is in. For example the spring housing **360** may have an angled shape as illustrated in FIG. **3**, or the spring housing **360** may be rounded. Other shapes may function in another manner to produce an acceptable result. A substance or structure **380** may cover much of the connector **300** to provide strain relief of the connector **300**.

A PC board **340** provides a physical support and electrical connections to signal processing circuits **350**. The processing circuits **350** process the signals from the DUT before they are passed through the coaxial cables **310** to the measuring device.

With reference to FIG. **4**, test signals from the DUT are passed from the springs **370**, through the processing circuits **350**, to a conductor **316** of the coaxial cable **310**. Similarly, ground connections **314** are coupled to another conductor of the coaxial cable **310**. The connector **300** of FIG. **4** is symmetric about the longitudinal axis, with a first signal being carried on one of the coaxial cables **310**, and a second differential signal carried on the other, as is known in the art. In other embodiments the connector **300** may only include a single signal path and convey only a single test signal.

With reference back to FIG. **3**, to couple the connector **300** to the test lead **200**, a user moves the connector toward the bracket **210** to mate with a spring latch **304** that includes a projection **308**. When inserted, the projection **308** is received and captured in a receiver, such as a depression or hole **212** in the bracket **210** to create a secure physical connection between the connector **300** and the test lead **200**. The secure physical connection also ensures that there is a secure electrical connection between the springs **370** and the probing signal pads **250**.

FIG. **5** illustrates another device to couple a measurement device with a DUT. In FIG. **5**, a connector **500** includes a head end **510** and a tail end **520**. The head end **510** attaches to the DUT in a similar fashion as the test leads **100**, **200**, described above, and is described in more detail below. A strap **502** carries electrical signals from the head end **510** to the tail end **520**, ending in a set of terminals **522**. The tail end **520** in this embodiment is structured to be inserted into a zero insertion force (ZIF) socket **526**, where the terminals **522** make an electrical connection with terminals within the ZIF socket **526**. In this embodiment, the test device, which is coupled to the ZIF socket **526**, may be connected to various different connectors **500** simply by removing the tail end **520** from a first connector and inserting a tail end from another connector. In practice the connector **500** may be left attached to the DUT, even after testing is completed. Of course, the tail end **520** may differ depending on implementation details.

FIG. **6** illustrates more details of the head end **510** of the connector **500**. The head end **510** of the connector **500** includes many of the same components as described in the test lead **200** and connector **300** described above, except the components are combined into a single unit.

More specifically, the connector **500** includes a strap **502**, which may be a flexible plastic that has conductive paths running through it. Signal pads **530** and ground pads **532** operate like their counterparts **130**, **132** described above with reference to FIG. **1**. Further, the connector **500** may be connected to the DUT using microsprings (not pictured) below the signal pads **530**, **532** and the other attachment mechanism, as described above.

A substrate, such as a PC board **504** provides physical support and electrical connections for the components **540**, **542**, mounted thereon. These components may vary depending on the particular signals being measured, but could include, for instance, resistors, capacitors, etc. An integrated circuit **546** modifies the signal before being measured, similar to the processing circuits **350** described above. Further, the connector **500** may include an identification device **550**, such as a memory device like an EPROM or EEPROM that may identify the particular connector **500** to the test device. Optionally, a tab **506**, which may be made of plastic or other material, may be attached to the connector **500**. The tab **506** allows the connector **500** to be more easily handled when attaching or, less likely, removing, the connector to the DUT. The tab **506** also provides physical protection for any delicate features that may be mounted on the connector **500**, such as the small connection wires **547**.

It will be appreciated from the forgoing discussion that the present invention represents a significant advance in the field of test and measurement. Although specific embodiments of the invention have been illustrated and described for purposes of illustration, it will be understood that various modifications may be made without departing from the spirit and scope of the invention. Accordingly, the invention should not be limited except as by the appended claims.

What is claimed is:

1. A measuring system for measuring signals from an electrical device, the measuring system comprising:
- a solder-less lead including:
  - a support bracket;
  - an attachment mechanism structured to securely attach the support bracket to the device,
  - a probe signal pad,
  - a microspring housing,
  - a microspring carried in the housing, a portion of the microspring extending beyond a surface of the microspring housing when the microspring is unsprung, and the microspring structured to electrically couple, on a first end, to the electrical device when the lead is attached to the device by the attachment mechanism, and couple to the probe signal pad on the second end; and
- a connector structured to be temporarily coupled to the solder-less lead, the connector comprising:
  - a latch structured to temporarily couple to the support bracket of the lead,
  - a microspring housing,
  - a microspring carried in the housing, a portion of the microspring extending beyond a surface of the microspring housing when the microspring is unsprung, and the microspring structured to electrically couple to the probe signal pad of the lead when the connector is coupled to the lead.

2. The measuring system of claim **1** in which the support bracket is positionable.

3. The measuring system of claim **2** in which the microspring housing of the connector is structured to position the microspring to electrically connect to the probe signal pad when the support bracket is in a first position, and when the support bracket is in a second position.

4. The measuring system of claim **1** in which the support bracket includes a receiver and the latch includes a projection, the receiver structured to receive the projection.

5. The measuring system of claim **1** in which the attachment mechanism is an adhesive pad.

6. A measuring system for measuring signals from an electrical device, the measuring system comprising:
- a lead structured to be attached to the electrical device, the lead including:
  - a signal pad,
  - a first spring housing, and
  - a first spring carried in the first spring housing, a portion of the first spring extending beyond a surface of the first spring housing when the first spring is unsprung, and the first spring structured to touch the electrical device and carry an electrical signal between the electrical device and the signal pad when the lead is attached to the electrical device; and
- a connector structured to be temporarily coupled to the lead, the connector comprising:
  - a second spring housing, and
  - a second spring carried in the second spring housing, a portion of the second spring extending beyond a surface of the second spring housing when the second spring is unsprung, and the second spring structured to electrically couple to the lead when the connector is coupled to the lead.

7. The measuring system of claim **6**, further comprising a printed circuit board coupled to the first spring housing, the signal pad being disposed on the printed circuit board.

8. The measuring system of claim **6**, further comprising a probing signal pad electrically coupled to the signal pad, the second spring being structured to electrically couple to the probing signal pad when the connector is coupled to the lead.

9. The measuring system of claim **8**, in which the second spring is structured to electrically couple to the probing signal pad when the connector is coupled to the lead.

10. The measuring system of claim **6**, further comprising:

a ground pad; and

a third spring electrically coupled to the ground pad and structured to touch the electrical device and carry a ground signal between the electrical device and the ground pad when the lead is attached to the electrical device.

11. The measuring system of claim **6**, further comprising a third spring carried in the first spring housing, a portion of the third spring extending beyond the surface of the first spring housing when the third spring is unsprung, and the third spring structured to touch the electrical device and carry a second electrical signal between the electrical device and the signal pad when the lead is attached to the electrical device.

12. The measuring system of claim **6**, in which the first spring and the second spring are torsion springs.

13. The measuring system of claim **6**, further comprising an attachment mechanism configured to securely attach the lead to the electrical device.

14. The measuring system of claim **6**, in which the attachment mechanism is a clamp.

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